Simulation of Richtmyer-Meshkov Instability, using the SPPM Code on the IBM SST System

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Progression of Simulation Size With ASCI Platform Evolution

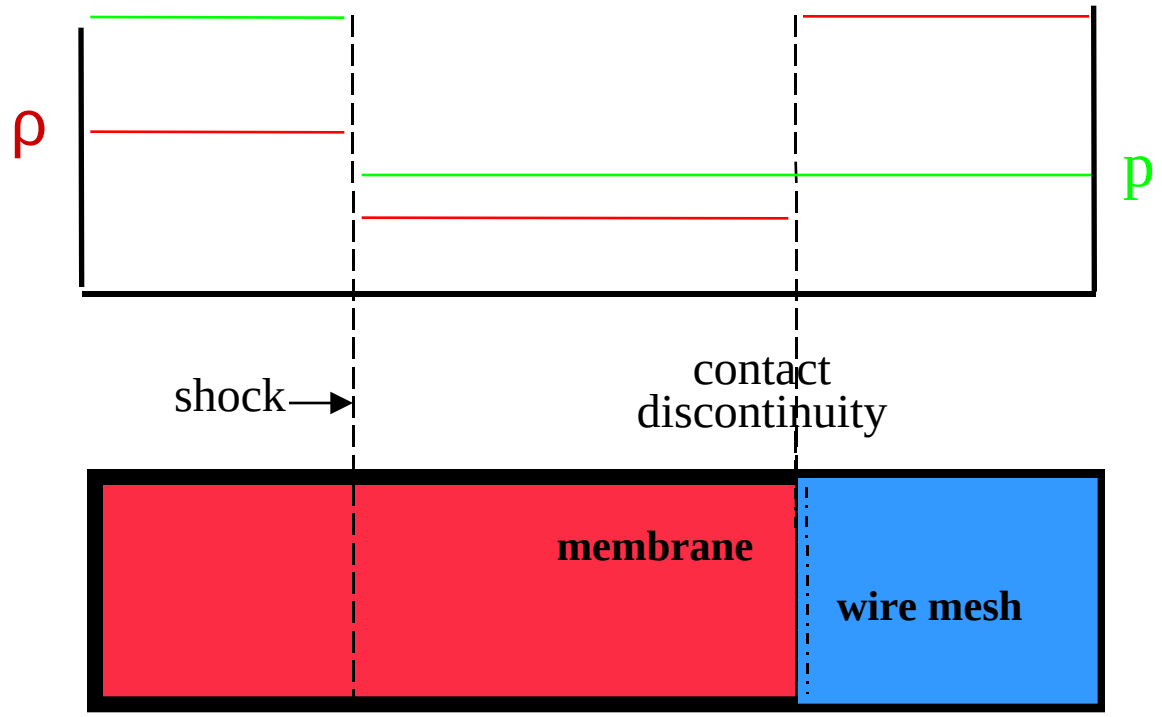
Date	Number of Gridpoints	Number of Processors	Sustained Throughput
4Q96	0.13 B	128	0.003 Tf
2Q97	1.10 B	512	0.013 Tf
4Q98	8.10 B	3840	0.50 Tf
4Q98	24.50 B	5832	1.20 Tf
4Q98	70.00 B	5832	--

Under-Resolved Hydrodynamics Will Be an *Enduring* Problem

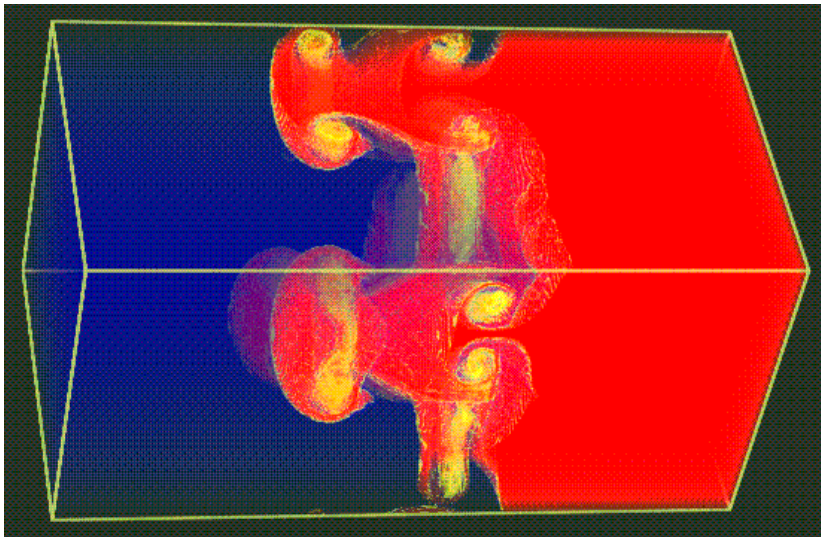
- **strong turbulence stimulates a wide range of space- and time-scales ($N_d \sim O(R_\lambda^3)$) ***
- **in 25 years, we've progressed from $R_\lambda \sim 30$ to $R_\lambda \sim 900$; our problems involve $R_\lambda > 10^6$**
- **full resolution of strong turbulence would require an $O(10^7)$-$O(10^9)$ - fold increase in computing capability (about 20-45 years *at recent rates*)**
- **3-dimensional large-eddy simulation will be the tool of choice**

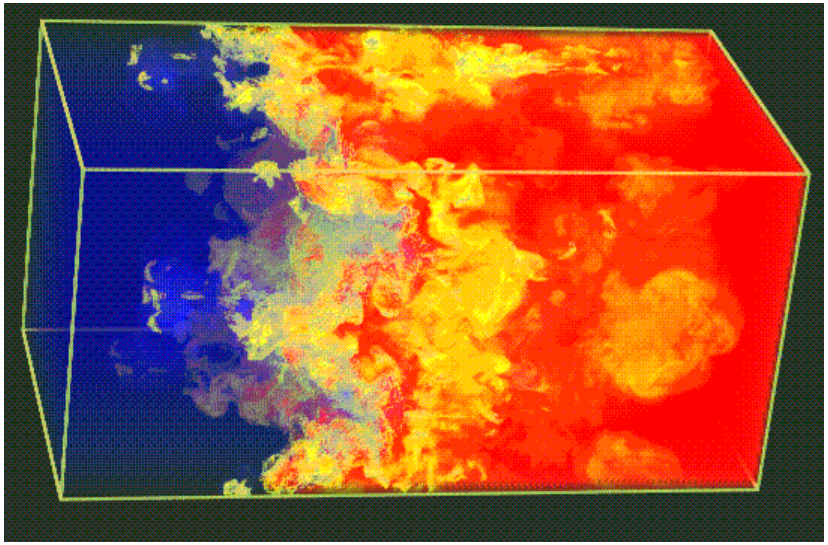
* R_λ is the *microscale* Reynolds number; $R_\lambda \sim O(Re^{1/2})$

RM Mixing Can Be Explored via Shock Tube Experiments

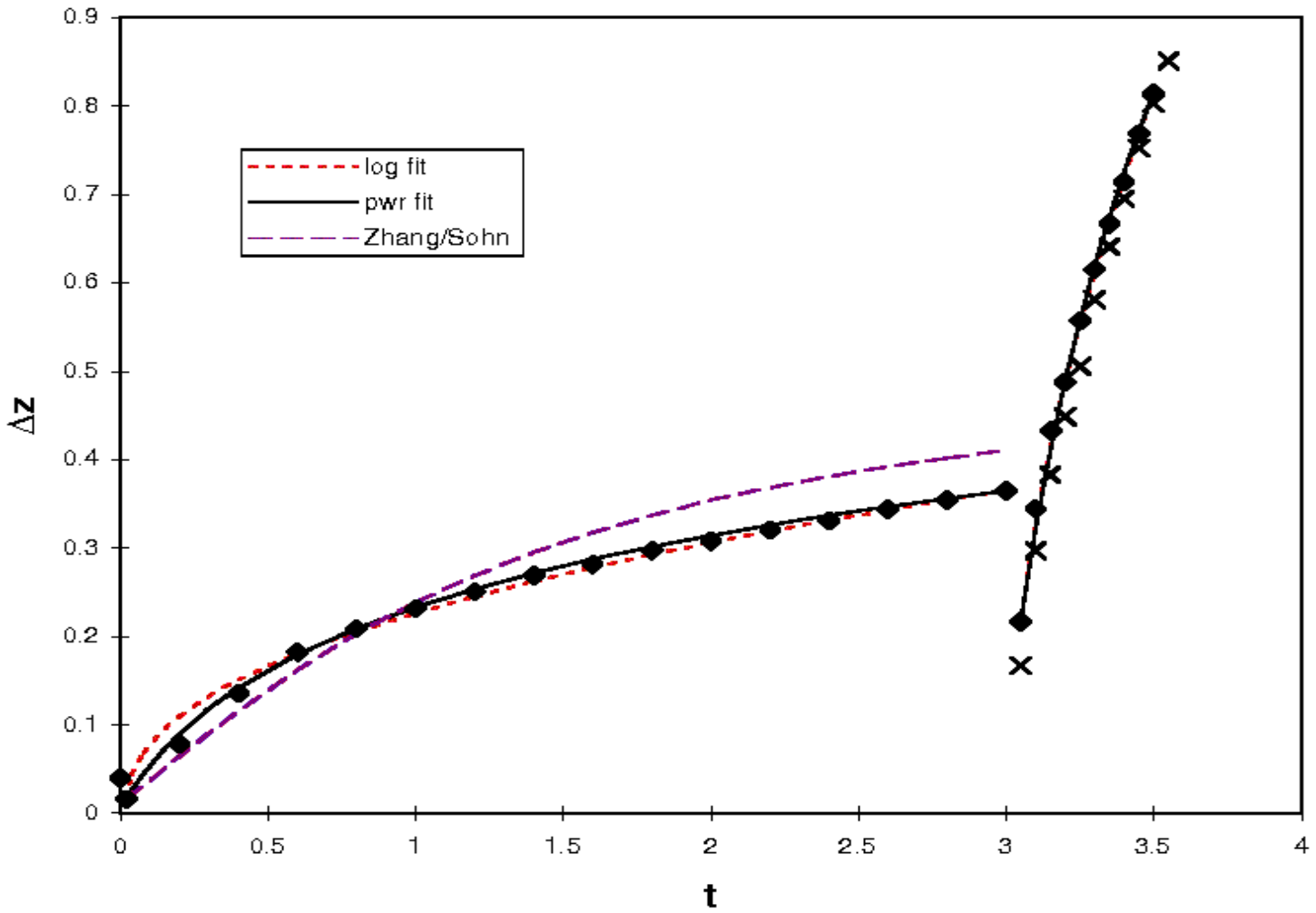


RM Multiple Shock Simulations (earlier experiments)





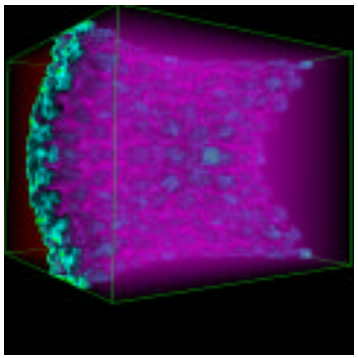
Mixed Layer Growth in Double-Shocked RM Simulation

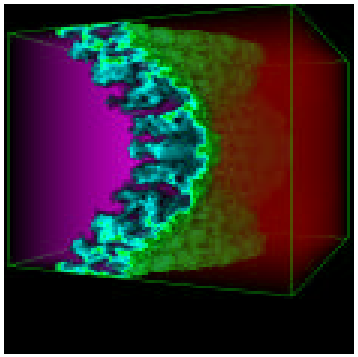


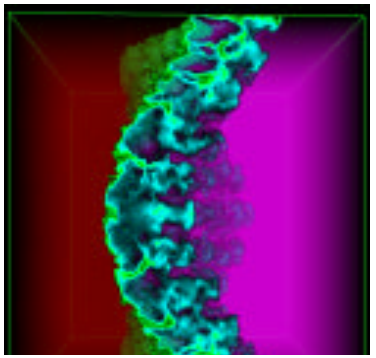
wpd6

Simulation Concept

- **in collaboration with A-Division**
- **mimics Caltech shock-tube experiment conditions with potential for *multiple shocks***
- **highest "feasible" resolution, about 2048^3 zones (grind time, not memory, is the limiting factor)**
- **initial conditions contain (1) single-mode long- wavelength and (2) multiple short-wavelength perturbations**







SPPM Code

- **Simplified Piecewise Parabolic Method (Colella and Woodward)**
  - **Godunov method**
  - **Lagrangian plus remap (effectively Eulerian)**
- **Three-dimensional domain decomposition**
- **Posix threads plus MPI**
- **Fortran 77**
- **32-bit arithmetic**

The SPPM Simulation on the IBM SST System

- 960 nodes of IBM SST
- 2048 X 2048 X 1920 mesh
- 8 X 8 X 15 domain decomposition
- 256 X 256 X 128 local mesh
- 27,000 timesteps
- 173 hours of full machine time, spread over 226 wall clock hours
- 129 MFlops (sustained) per processor
- 494 GFlops sustained throughput

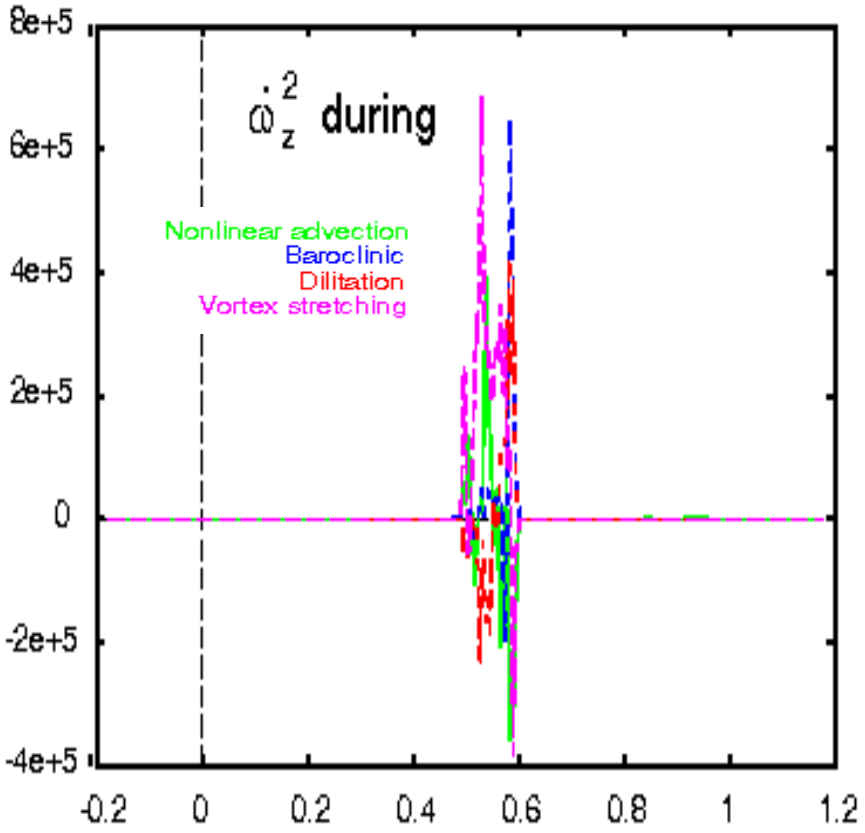
Output Procedures and Statistics

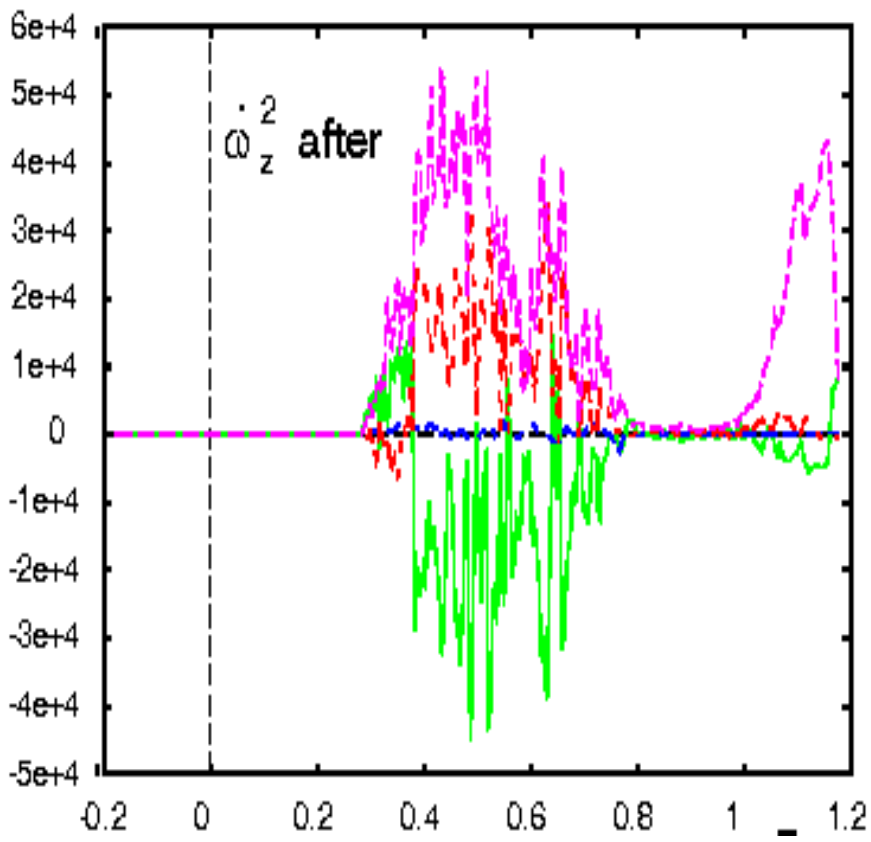
- **Restart dumps**
  - 960 nodes X 196 MB = 188 GB
  - backup copy on neighboring node
- **Bob dumps (movie frames)**
  - 274 frames X 960 nodes X 8.4 MB = 2,210 GB
  - 10:1 compression results in 221 GB
- **Compressed data dumps (16-bit integer)**
  - 10 dumps X 960 nodes X 84 MB = 806 GB
- **275,000 files to store**
- **Data flow: local disk, to GPFS, to Riptide, to FAST storage**

Expected Impact

- explores nonlinear interactions between short and long wavelength energy transfer and resulting effects on mixing
- largest calculation of its type
- high resolution allows capture of fine-scale physics, e.g., possible multiple transitions from coherent to turbulent states with increasing Reynolds number
- elucidates vital differences between 3-D and 2-D turbulence
- simulation diagnostics will provide tests of sub-grid scale parameterization model performance

Advanced Diagnostics Will Provide Important SGS Model Performance Tests





Next Steps

- simulation must be extended through second-shock event and subsequent mixing processes
- post-processing diagnostics tools must be extended to full-size dataset capability
- new laboratory experiments will likely be defined to facilitate verification and validation of simulation and to further test SGS model performance